

THE WEATHER AND CIRCULATION OF MARCH 1965

A Cold Month with a Strong Blocking Ridge in the Gulf of Alaska

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1. INTRODUCTION

March temperatures averaged below normal over all but a few small sections of the country. It was the coldest March in over 70 years at several cities in the northern Plains and the second coldest in more than half a century elsewhere in the Plains and the Midwest. The cold was persistent, both from the previous month [1] and during March, and was quite extreme after mid-month. All-time minima for so late in the season were reported in at least 20 States.

Temperatures were lower this month as a result of retrogression of blocking from the Atlantic to the eastern Pacific. Although much reduced from its February intensity, the major blocking ridge was ideally located in March to direct cold air from northern to southern sections of North America.

Shortly after mid-month a severe storm emerged from the Southwest, generating numerous tornadoes and one of the worst blizzards of the cold season. Schools were closed and roads were blocked for days after the storm, and the heavy snowfall, added to the existing abnormal snow cover, caused early concern over the flood potential in the Upper Mississippi Valley.

2. BLOCKING AND THE MEAN CIRCULATION

Early in March the principal center of blocking activity shifted suddenly westward from the Atlantic to the Gulf of Alaska. Thereafter the blocking center remained nearly stationary and slowly weakened through March. Its impact on the 700-mb. monthly mean circulation appeared in the amplified character of a mean ridge across the eastern Pacific and the Yukon (fig. 1) with maximum height anomalies of +500 ft. (fig. 2).

Some aspects of the behavior of blocking this month are illustrated by paths of selected 5-day mean height anomaly centers shown in figure 3. In late February the most intense positive center was located between Iceland and southern Greenland. During the next week it moved to Davis Strait while rises spread westward across Canada and a new center (discontinuous retrogression) appeared in Alberta. By March 11 the dominant positive center was in the Gulf of Alaska and blocking

had disappeared from the vicinity of Greenland. It returned later on, however, and a second positive center can be traced from Greenland to Hudson Bay from mid- to late March. This accounts for the eastward extension of positive height anomalies from the Gulf of Alaska to Denmark Strait in the monthly average (fig. 2). A correspondingly elongated region of negative anomalies stretched across the United States and the Atlantic. This negative channel was largely made up by the strong negative center (fig. 3) which moved eastward from Texas to the central Atlantic, steered by fast confluent westerlies.

While the blocking ridge (fig. 1) was at about the normal location for March ridges over the Yukon, farther south it was displaced about 800 mi. west of normal off the Washington coast. Wavelengths were short downstream with one more wave than normal from the eastern Pacific to the western Atlantic. From there eastward to the mid-Pacific the mean waves were close to their normal positions. The trough extending southward from a Low near Spitzbergen (fig. 1) was abnormally strong in the north, as also was the ridge north of the Himalayas. The mean Low off the Asiatic coast was south of normal and the associated trough was intense, with negative height anomalies prevalent from China eastward through the central Pacific.

With blocking across Canada to Iceland and deep troughs over Scandinavia and the western Pacific, the principal path of maximum west winds (fig. 4) was south of normal around most of the Northern Hemisphere. One exception was the eastern Pacific where the jet and associated storm tracks were diverted sharply northward by the blocking ridge. To a lesser degree the jet was also displaced northward north of the Siberian ridge. Mean wind patterns near the east coasts of Asia and North America were grossly similar, in that two branches of maximum west winds converged off both coasts. In addition wind speeds averaged as high as 25 m.p.s., about 10 m.p.s. faster than normal, just downwind from these junctures.

Early March marked the lowest point in the long index cycle which began in late January. During the cycle the temperate westerly index (35° to 55° N., 0°

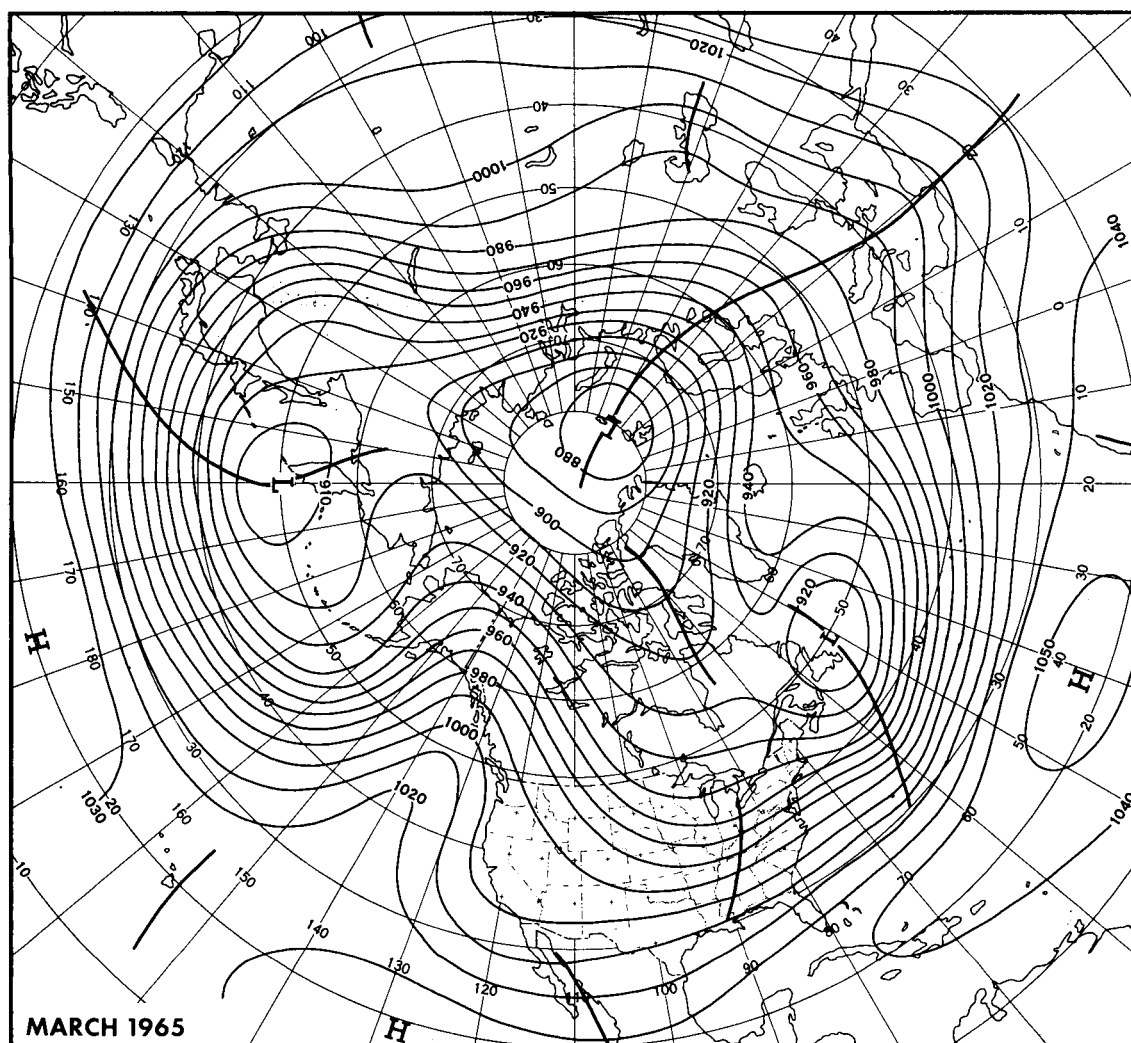


FIGURE 1.—Mean 700-mb. contours (tens of feet) at intervals of 100 ft. for March 1965. Most prominent feature was the blocking ridge across the Yukon and eastern Pacific.

westward to 180° W.) fell rapidly from January 21 to February 1, leveled off, then again dropped sharply from February 25 to March 4. Figure 5 shows a plot of these 5-day indices with dates at mid-period. After the minimum of 4 m.p.s. was reached on March 4 the index rose steadily to a peak of 10.6 m.p.s. on March 25. Temperatures reacted to the cycle in rather typical fashion with coldest anomalies lagging behind the lowest circulation index.

3. TEMPERATURE

Cold weather over the United States is to be expected with positive height anomalies over the Yukon and negative height anomalies in the States. Such was the case this March (fig. 2) when below normal temperatures prevailed over the country except for parts of the Far West, Florida, and New England (fig. 6A). Tempera-

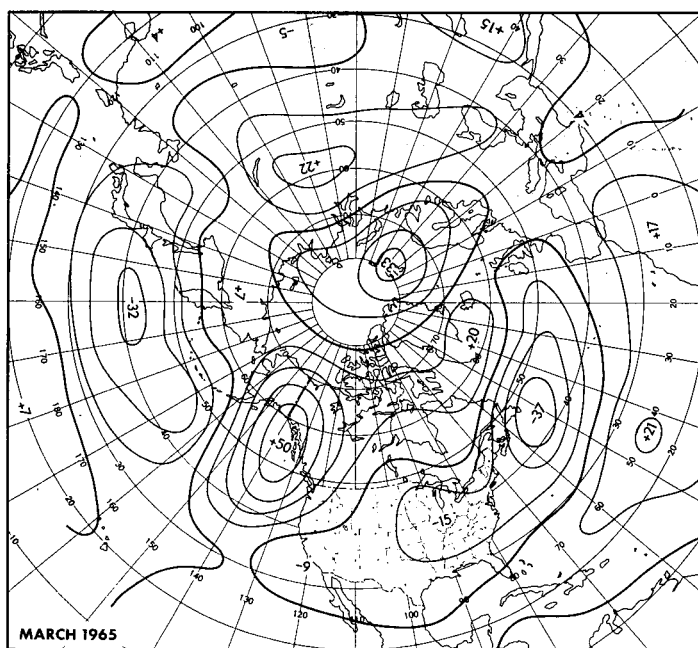


FIGURE 2.—Mean 700-mb. height departures from normal for March 1965 at intervals of 100 ft., centers in tens of feet and the zero isopleth heavy. Blocking is indicated by large positive anomaly center near Gulf of Alaska and its extension across Canada to Denmark Strait.

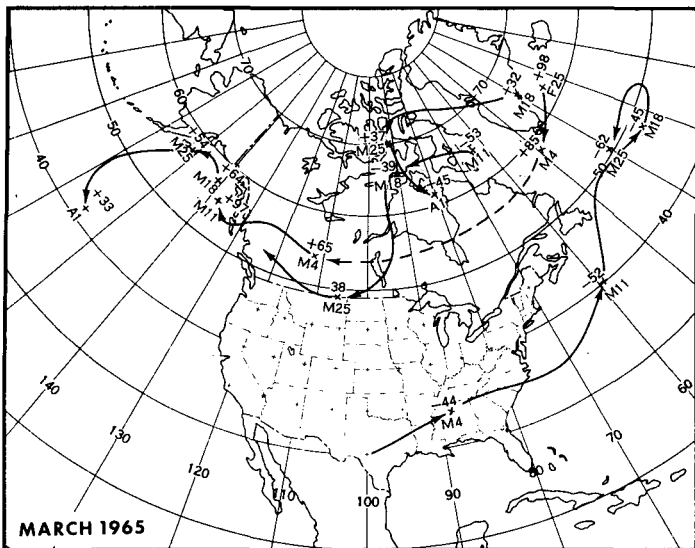


FIGURE 3.—Smoothed tracks of selected 5-day mean height anomaly centers at 700 mb. in March 1965. Central value and sign of anomaly is given above weekly positions, month and central day of 5-day period below. Solid arrows are actual paths; dashed arrow is axis of height rises (blocking wave) during the week prior to March 4.

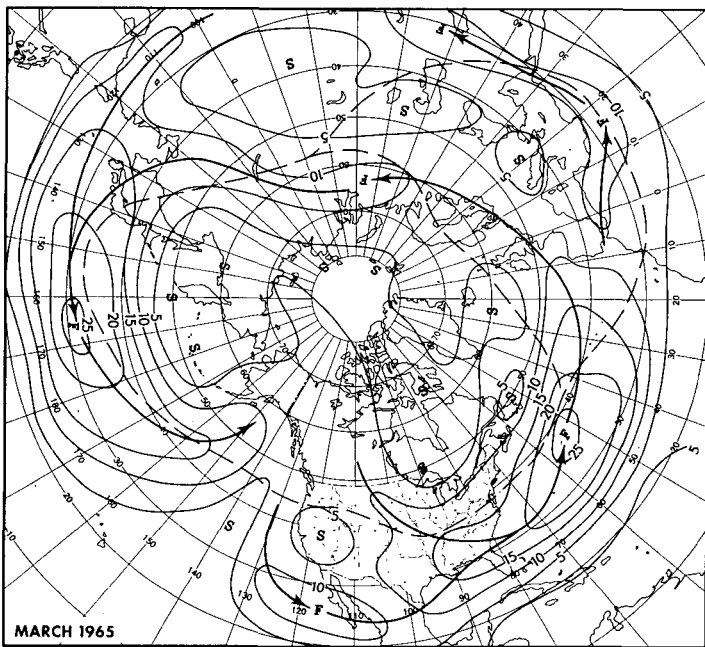


FIGURE 4.—Mean isotachs (meters per second) at 700 mb. for March 1965. Solid arrows indicate the primary observed axis of maximum wind speed, dashed lines the normal. Average maximum westerlies were south of their usual position around most of the Northern Hemisphere.

tures in the much below category predominated over the middle third of the Nation with greatest departures in the northern States. Cooling by one or more anomaly classes (out of 5) occurred at 66 of 100 standard locations from February to March despite the fact that more than half the country averaged below normal in February [1].

During the first two weeks of March, while blocking retrograded across Canada, temperatures across most of the northern tier of States averaged above normal. But once the blocking ridge became established in the eastern Pacific, very cold air flooded most of the country. The cold was so intense that averages this March were the lowest this century in parts of Montana, Wyoming, Colorado, Nebraska, Minnesota, and North Dakota. It was the second coldest March at scattered points in the Plains States from Missoula, Mont. to Fort Worth, Tex. At several stations in the Midwest average temperatures were lower only in March 1960, when they were reported 2 to 3 standard deviations below normal [2].

Lowest temperatures so late in the season were reported this month at stations in most States east of the Continental Divide, except in the Northeast and the Southeast. Nearly all these low temperatures occurred after mid-month. Other temperature highlights were: 29 consecutive days with temperatures below normal at Phoenix, Ariz.; 10th consecutive cool month at Boston, Mass., the 8th at Aberdeen, S. Dak.; and -23°F . on the 25th, an all-time March low at Sheridan, Wyo.

4. PRECIPITATION

Precipitation exceeded normal over extensive areas of the Southwest, the East, and the Upper Mississippi Valley (fig. 6B). Totals were much less than normal in the Pacific Northwest, just east of the Continental Divide (except Montana), and in New England. Heavy precipitation is known to correlate well with cyclonic circulation in the Southwest, such as that of figure 1. This was the first month since June 1964 with rainfall above normal at San Diego, Calif.

Amounts were unusually heavy west of the Great Lakes where the circulation was also cyclonic. Several new snowfall records were established in the Great Lakes Region. It was the snowiest March of record at Grand Rapids, Mich., St. Cloud, Minn., Erie, Pa., and Milwaukee, Wis. Unusually extensive snow cover helped lower temperatures in this and adjacent regions.

In the Southeast, along and ahead of the mean trough from Ohio to Louisiana (fig. 1), precipitation totals were more than 8 in. in many places. This was rather evenly distributed throughout the month so that field operations were seriously hampered by wet soil.

Anticyclonic circulation with the blocking ridge caused extremely dry sunny weather over Washington and Oregon. March precipitation was only $\frac{1}{4}$ to $\frac{1}{2}$ of normal in those States and in western Oregon consecutive rainless days equaled the March record of 21 days. Another dry area included New England, where the upper flow was northwesterly and slightly anticyclonic. It was the second driest March at Burlington, Vt., and Portland, Maine. Parts of the southern and central Plains were also dry with downslope or neutral geostrophic components of anomalous height flow. In parts of Montana and Idaho the anomalous flow was directed upslope so that precipitation

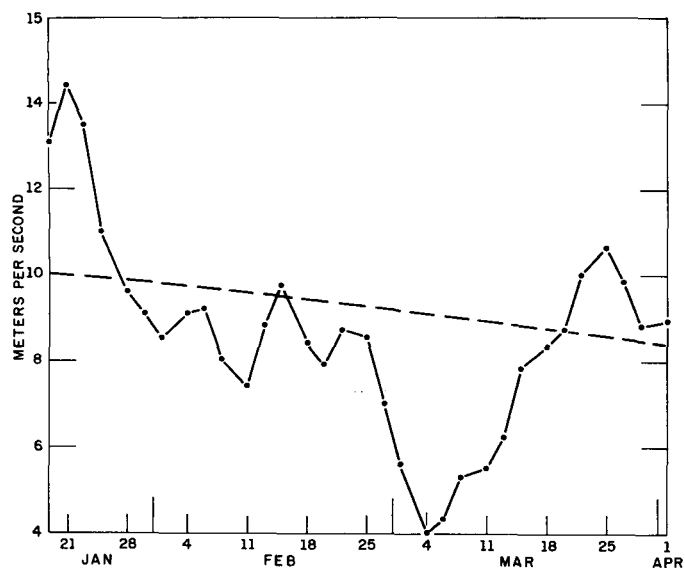


FIGURE 5.—Variation of 5-day average wind speeds (zonal index, meters per second) at 700 mb. for western half of the Northern Hemisphere, 35° to 55° N., from late January to April 1, 1965. Solid lines connect values at middle of 5-day periods, dashed line the normal. A pronounced index cycle began late in January and ended late in March.

was about normal despite the scarcity of daily cyclones and the deficiency of Pacific moisture implied by the mean circulation.

4. WEEKLY EVOLUTION

MARCH 1-7

Blocking spread rapidly westward from the center near southern Greenland during the first week as positive height anomalies prevailed at higher latitudes of the Atlantic and North America (figs. 7A, B). Compensating intense negative anomalies were observed at lower latitudes. This extreme circulation pattern was accompanied by the lowest values reached in the index cycle of early 1965.

Warm dry weather prevailed in the Northeast and the Pacific Northwest this week (figs. 7C, D) under a decidedly anticyclonic circulation regime. In southern California it was warm and wet with the approach of a mean trough toward the coast. Unseasonably cool weather was observed over the rest of the country where the circulation was more cyclonic. The mean Low over the middle Mississippi Valley (fig. 7A) was made up by a huge daily low pressure system which moved from Louisiana early in the week, then became stationary. This Low brought cold cloudy weather to a large area, and snowfall up to 6 in. in Texas, 4 in. in Louisiana, and near blizzard conditions in southwestern Iowa and Minnesota. Snow measured 21.7 in. from a severe snowstorm March 1-3 at St. Cloud, Minn.

MARCH 8-15

Vigorous blocking not only dominated the eastern

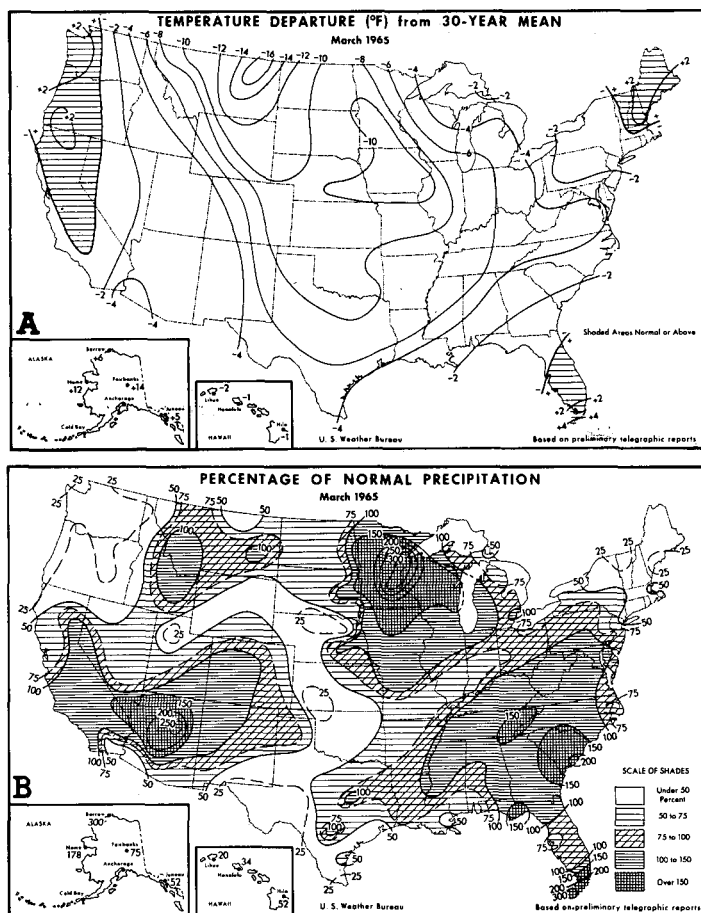


FIGURE 6.—(A) Temperature departure from normal (°F.), and (B) percentage of normal precipitation, for March 1965. (From [3].)

Pacific and western North America this week but also spread upstream to the western Aleutians (figs. 8A, B). At the same time the blocking ridge of the previous week in Davis Strait was replaced by a deep trough and heights there fell as much as 1,100 ft. Confluence was pronounced between the northwesterly current from Canada and the west-southwesterly flow from the California trough.

Reaction of temperature anomalies to the confluence is indicated by warming (fig. 8C) in southern Texas and the rather sharp anomaly gradient along the Gulf Coast. This was the third consecutive week with average temperatures 3° to 6° F. below normal from Louisiana and Arkansas eastward. Remnants of anomalous warmth from earlier blocking remained over the northern tier of States. Effects of the confluence on the precipitation show in figure 8D as a streak of heavier precipitation from the Texas Panhandle to the south Atlantic coast. In Washington and Oregon it was the second straight abnormally dry and sunny week. By contrast, the progressive California trough spread moderate to heavy precipitation across the Southwest.

MARCH 15-21

Circulation changes from the second to the third week

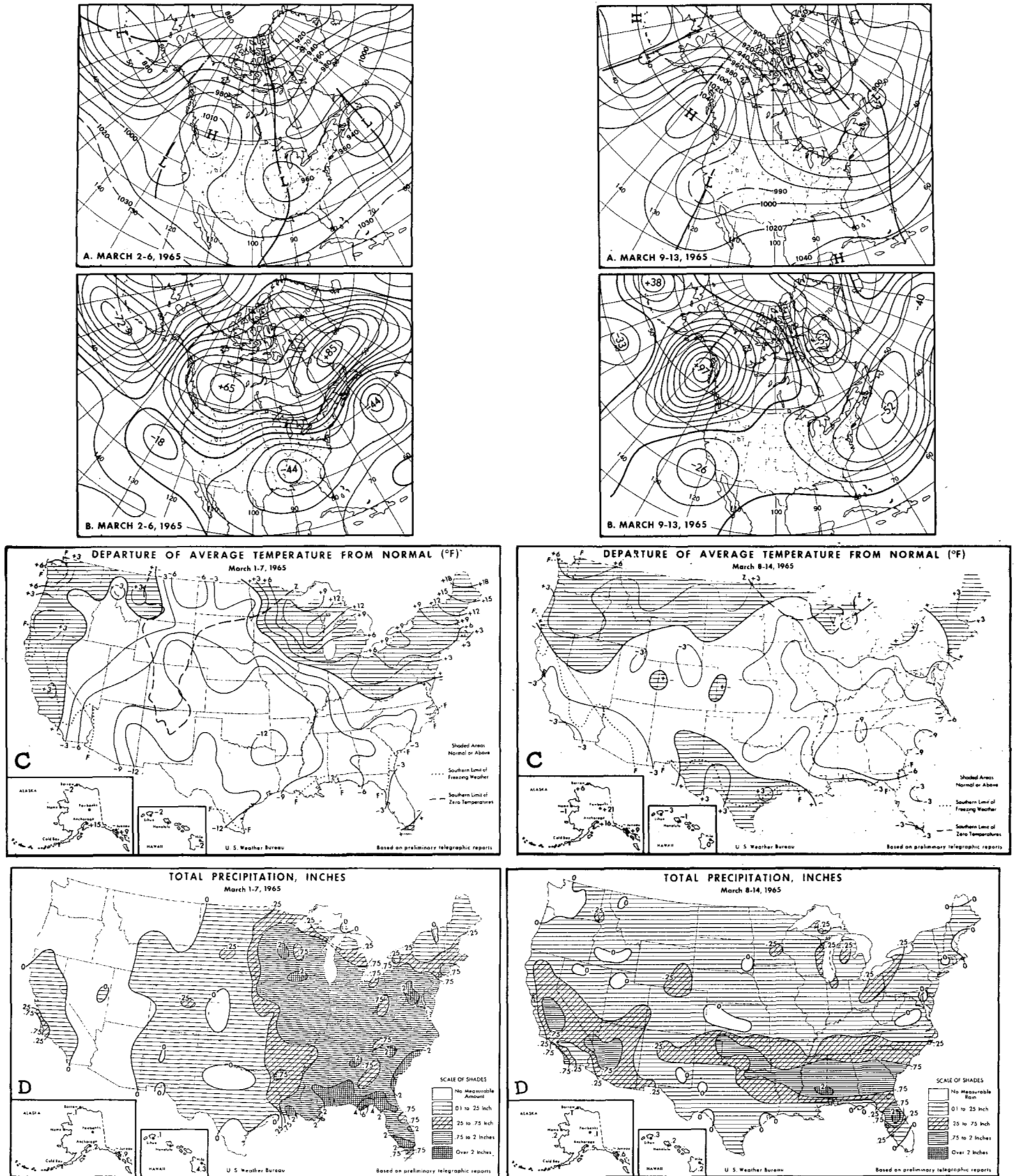


FIGURE 7.—(A) Mean 700-mb. contours (tens of feet); (B) mean 700-mb. height departures from normal (tens of feet) for March 2-6, 1965; (C) temperature departure from normal (°F.); and (D) total precipitation (in.) for March 1-7, 1965. (C and D from [3].)

FIGURE 8.—Same as figure 7 except (A) and (B) for March 9-13; (C) and (D) for March 8-14, 1965.

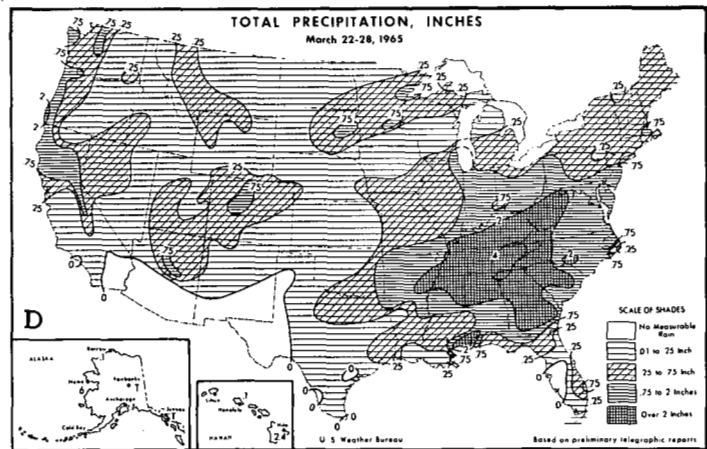
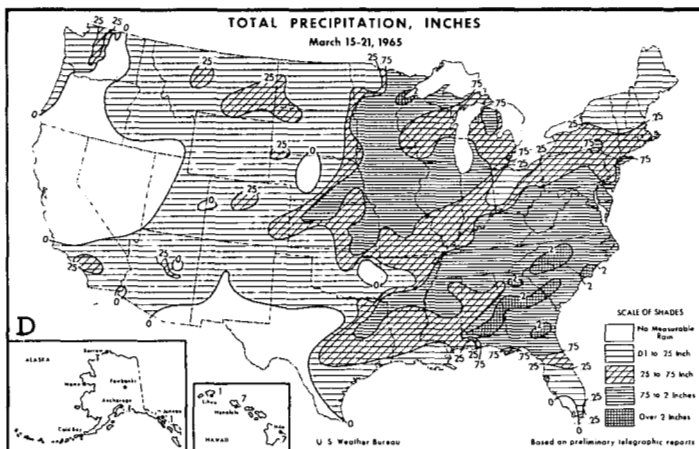
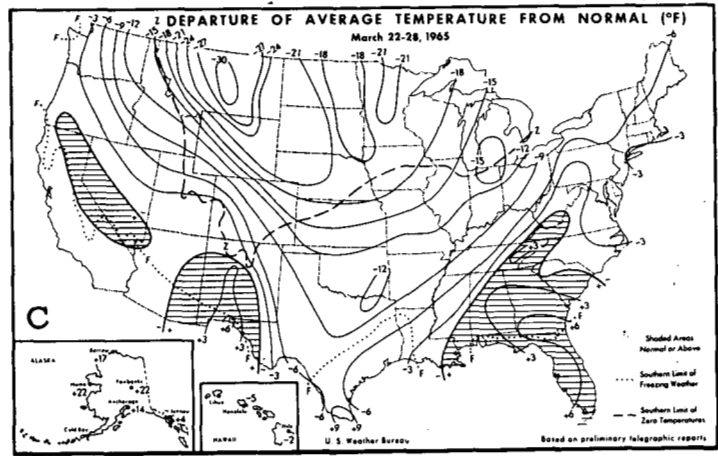
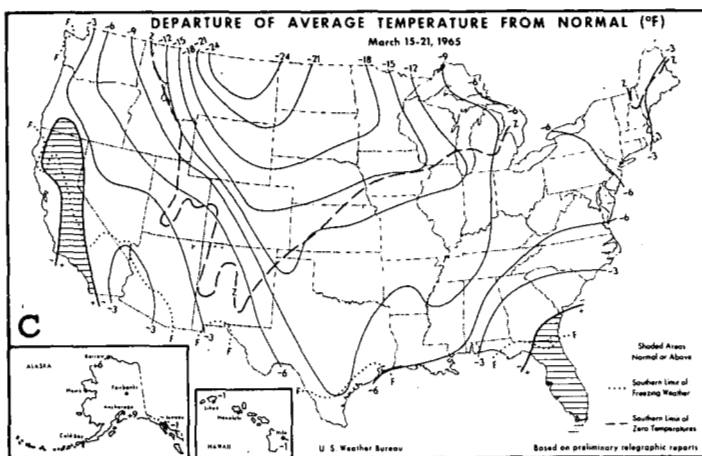
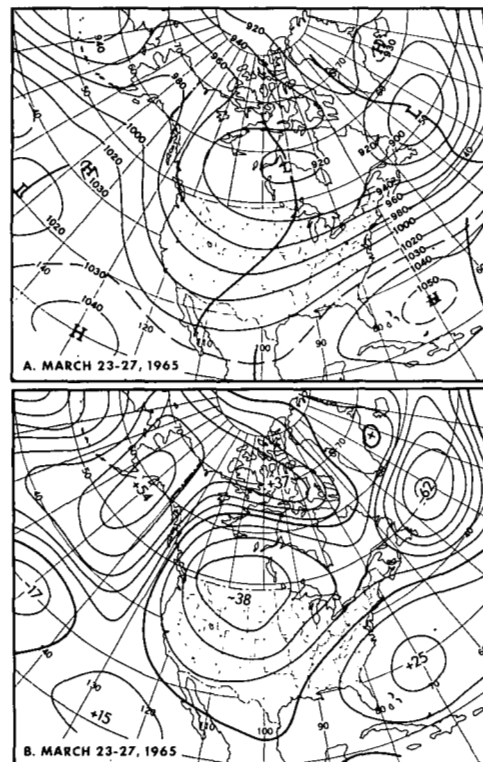
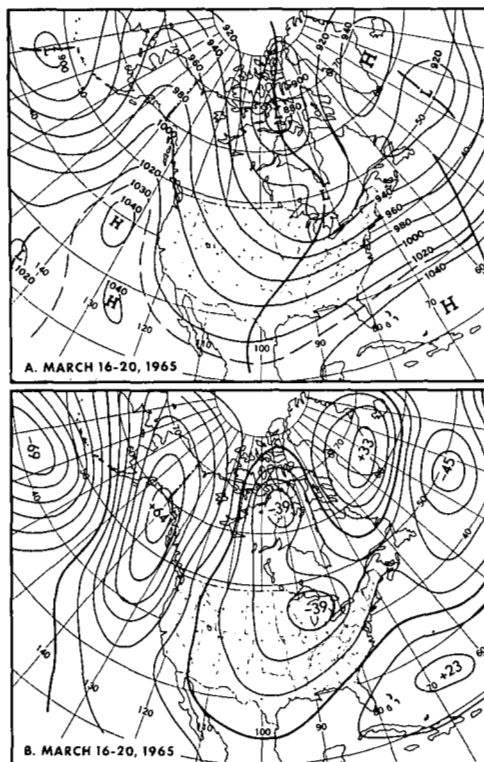


FIGURE 9.—Same as figure 7 except (A) and (B) for March 16-20; (C) and (D) for March 15-21, 1965.

FIGURE 10.—Same as figure 7 except (A) and (B) for March 23-27; (C) and (D) for March 22-28, 1965.

were characterized by retrogression of the wave pattern at high latitudes and by progression at low latitudes. The blocking ridge in the eastern Pacific weakened while a new blocking wave appeared in the Atlantic (figs. 9A, B). Retrogression of the Davis Strait trough to central Canada enhanced the northerly flow over western North America. This trough combined with the advancing California trough to form a deep full-latitude trough over mid-Continent.

Emergence of the Southwest trough brought with it a tremendous Colorado-type storm which caused one of the worst blizzards of the winter in the northern Plains. In Minnesota, Wisconsin, and adjacent areas schools were closed and roads were blocked. At one observation Duluth, Minn., reported a snow depth of 48 in. Severe weather occurred farther south with numerous reports of tornadoes in parts of the central Plains, Midwest, and South on the 16th and 17th.

Behind the storm Arctic air spread quickly to the Gulf of Mexico with zero ($^{\circ}\text{F.}$) temperatures reaching as far south as New Mexico. New minima for so late in the season were recorded late this week in Texas, Mississippi, Tennessee, West Virginia, Wisconsin, Minnesota, and Colorado. At Lynchburg, Va., 7°F. on the 21st was the coldest March temperature of record. Average temperatures for the week (fig. 9C) were almost entirely below normal over the Nation except in California and Florida. Precipitation (fig. 9D) was generally less than $\frac{1}{4}$ in. in the western half of the Country but $\frac{1}{2}$ to $1\frac{1}{2}$ in. over the eastern half.

MARCH 22-28

The new blocking surge in the Atlantic continued to push westward across northern Canada where it merged with the persistent ridge in the Gulf of Alaska. At the same time the principal mean Low aloft in Canada was displaced southward. This circulation was ideal for producing cold weather over most of the Country with nega-

tive height anomalies in all but Southeast sections and cyclonic northwesterly flow in the West (figs. 10A, B). Average temperature departures for the week ranged to -30°F. in central Montana, and -15°F. as far south as central Kansas and east to Ohio (fig. 10C). As during the previous week, numerous unprecedented low temperatures for so late in the season were recorded, this time from the northern Rockies eastward through Ohio. The unseasonable cold prevented normal growth of pastures and fall seeded grains as far south as the southern Plains. Temperature trends were not all lower; there was considerable warming over the southern Rockies and the Southeast.

Heavy snow cover from the Red River of the North to Lake Huron not only contributed to low temperatures but also was considered a potential flood threat, depending on weather conditions in the following few weeks. Rainfall totaled 2 to 4 in. over a large area from eastern Arkansas to the southern Appalachians (fig. 10D), further delaying land preparation in the Southeast. In Washington and Oregon the dry spell which began about March 1 was ended by light rains from the first storms this month to penetrate the blocking ridge. Dry conditions persisted in the "rain shadow" east of the Divide from New Mexico to southwestern Kansas. By the end of March storms entering the west coast were deeper, considerable rainfall was reported from southern California to Washington, and warming continued over the Rockies and parts of the South.

REFERENCES

1. L. P. Stark, "The Weather and Circulation of February 1965—Strong Atlantic Blocking," *Monthly Weather Review*, vol. 93, No. 6, May 1965, pp. 336-342.
2. C. R. Dunn, "The Weather and Circulation of March 1960—A Cold Snowy Month," *Monthly Weather Review*, vol. 88, No. 3, Mar. 1960, pp. 112-120.
3. U.S. Weather Bureau, *Weekly Weather and Crop Bulletin*, vol. 52 Nos. 10-14, Mar. 8, 15, 22, 29, Apr. 5, 1965.